

FACILITY FORM NO. 1
N 65-20810
(ACCESSION NUMBER)
(PAGE(S))
CB 57669
(NASA CR OR TNX OR AD NUMBER)

(THRU)
(CODE)
03
(CATEGORY)

Anthony

HYDROGEN-OXYGEN ELECTROLYTIC REGENERATIVE FUEL CELLS

Prepared for

National Aeronautics and Space Administration
Lewis Research Center
21000 Brookpark Road
Cleveland 35, Ohio
Attn: D. G. Soltis

Contract NAS 3-2781

EOS Report 4110-M-8

10 May, 1964

Prepared by

Harvey Frank
Harvey Frank
Project Supervisor

GPO PRICE \$ _____

OTS PRICE(S) \$ _____

Hard copy (HC) *\$1.10*

Microfiche (MF) *.50*

Approved by:

E. Findl
E. Findl
Manager, Chemical and
Fluid Systems Dept.

A. R. Tanguay
A. R. Tanguay
Manager
Energy Conversion Division

TABLE OF CONTENTS

1. Introduction	1
2. Technical Discussion	1
2.1 Fuel Cell Assembly	1
2.2 Permeability Studies	3
3. Plans for May	4
4. Financial Statement	5

1. INTRODUCTION

This report briefly reviews the progress made on the development of a rechargeable fuel cell (NAS Contract 3-2781) during the month of April, 1964. Several modifications were performed on the fuel cell assembly, and the unit was operated through two cycle tests. A study was also initiated to measure the gas permeability of the various types of asbestos matrices which are employed within the cells. Work on the final report has been initiated.

2. TECHNICAL DISCUSSION

2.1 Fuel Cell Assembly

Several modifications of the fuel cell were carried out in order to eliminate possible sources of the malfunctions described last month. Measurements with the differential pressure transducer, described last month, indicated a linear increase in differential hydrogen pressure with state of charge. This result indicated an insufficient hydrogen tank volume, i.e., less than the required 2/1 volume ratio for H_2 and O_2 respectively. This improper gas volume ratio was most likely one of the causes for the internal ignition, i.e., imbalanced pressures leading to gas mixing and subsequent ignition by the catalysts. The problem was temporarily resolved by connecting a small steel container to the hydrogen side of the assembly. Subsequent tests revealed that the differential pressure did not vary appreciably throughout the cycle, indicating that the required 2/1 gas volume ratio was achieved.

A second change was concerned with the bellows pressure equalizer. In this case it was decided to employ a fabric reinforced type of rubber for added strength. An order was subsequently placed with a local vendor to fabricate nylon reinforced viton rubber bellows.

The vendor reported difficulty in fabricating with viton, but that he could readily make them if silicone rubber was substituted. A nylon reinforced silicone bellows was subsequently obtained and installed on the assembly. The size of this bellows was intentionally made somewhat larger than the previous design in order to compensate for the improper volume ratio (described above), and thereby eliminate the need for the additional hydrogen container.

A third change consisted of installing a new set of hydrogen electrodes which contained only platinum as a catalyst. Previously these electrodes contained a mixture of both platinum and palladium catalysts. The reason for this change was based on the known high reactivity of palladium in regard to ignition of H_2-O_2 mixtures. It was therefore anticipated that there would be less likelihood of another internal ignition should gas mixing occur in the assembly.

A fourth and final change consisted of adding more electrolyte to the asbestos matrices before assembly. The change corresponded to an increase in the ratio of electrolyte to asbestos from 0.6 to 0.7 grams of 25 percent KOH per gram of dry asbestos. The purpose of this change was to insure that there would be sufficient water within the asbestos matrices at the high state of charge, and thereby minimize the possibility of internal gas diffusion at this state.

When all of these modifications had been completed, the unit was readied for cycle testing. The unit was found to function very well for five cycles. The power output during each of the discharge periods was in excess of the required 75 watts, and the charge voltage was less than 10 volts for each charge period. During the discharge portion of the 6th cycle, however, an abnormal drop in voltage, and a rapid pressure drop and rise in internal temperature was noted. During the subsequent charge period, an abnormally low charge voltage was also noted. These results all pointed to the probability of an internal short circuit of one of the cells. The unit was subsequently turned off and disassembled. Inspection of the cell stack confirmed

the presence of a shorted cell, first by probing with an ohmmeter, and second by visual examination. The cause for the internal short was found to be associated with the teflon gaskets. The knife edge seals of two adjacent separators had apparently cut through the gaskets, and caused metallic contact of two adjacent cells. The gasket had been employed on previous runs, and had been deformed via cold flow of the teflon to a thickness of $\sim 0.030''$. (Normal gasket thickness is $0.043''$)

A new set of teflon gaskets was subsequently obtained from a local vendor. Inspection of this new set revealed small dimensional deviations from the required specifications. There was therefore some concern as to whether to continue testing with this new set of gaskets. The gaskets were reworked, and it was decided to attempt another test run.

In the next test, an internal ignition occurred during the latter portion of the discharge period of the first cycle. Disassembly and examination of the cell stack revealed the source of the ignition to be associated with one of the new teflon gaskets. The gasket had been extruded to such an extent in the initial assembly that there was a direct opening between a hydrogen gas port and an oxygen electrode.

This latter result reaffirmed the need for maintaining very rigid control over the gasket material and condition for this unit. After a careful review, it was decided to change the material of construction of the gaskets from teflon to viton. It is anticipated that this change will avoid the cold flow and resultant problems associated with the teflon gaskets.

2.2 Permeability Studies

Initial leak tests on this assembly revealed that the cell stack could withstand only a very slight pressure differential, i.e., less than 1 inch of water. The low resistance to gas flow was traced to the asbestos matrices. In changing from one layer of the old type of asbestos ($0.070''$ thick) to two layers of a new type $0.035''$ thick),

the cell stack was found to be much more resistant to pressure differential and internal gas flow. Since the gas permeability of the cell stack is directly associated with the internal ignition problems, it was deemed advisable to make a more thorough study of the permeability of the asbestos matrices.

A gas permeability apparatus was subsequently assembled, and a series of tests was initiated on the asbestos matrices. The thickness, number of layers, and grade of asbestos matrices were selected as the parameters for the first test series. The initial results indicate that permeability is a very strong function of both of the above variables. For example, using one layer of the old grade of 0.070" asbestos, it was found that less than 0.5 psig of H_2 was sufficient to cause bulk gas flow. On the other hand, two layers of 0.035" asbestos currently employed was found to hold 6 psig. with zero gas flow. Another grade, 0.020" thick, was found to withstand the greatest differential, i.e., 2 layers withstood 10 psig. A three layer matrix containing one layer of 0.020" between two layers of 0.035" material was found to hold 12 psig. A complete summary will be given in the final report.

3. PLANS FOR MAY

The unit will be modified so as to accommodate viton gaskets, and a new set of asbestos matrices consisting of two layers of 0.035" asbestos plus one layer of 0.020" asbestos. After initial check out tests, the unit will be carried through the required 48 hr. cycle tests. Permeability studies will also be continued with a study of the effect of electrolyte content and compression of the matrices on permeability.